TRANSLATION

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TRANSMISSION-TYPE DISPLAY ELEMENT

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Specification

Title of Invention

TRANSMISSION-TYPE DISPLAY ELEMENT

Scope of Patent Claim

(1) A transmission-type display element which is characterized by the fact that in a transmission-type display element that has a substrate made from at least one or several pieces of a transparent substance and a display substance supported on this substrate and the irradiated light from the back of said substrate is controlled by the aforementioned display substance to perform display, the back of the rear part of the aforementioned substrate is worked to obtain an irregularly shaped microlens array.

Detailed Explanation of Invention

[Technological field]

This invention pertains to a transmission-type display element with which transmission-type display of a bright image plane is possible.

[Conventional technology] [Prior art]

At the present time, CRT (cathode-ray tubes) are the main display devices used to display writing and television images. However, CRTs have a disadvantage in that they have a large volume and therefore, a variety of thin display elements have been presented and some are being used in place of the CRT. These display elements can be divided into photo-emitting and photo-receiving types. Plasma display, fluorescent display tubes, electroluminescence display, photo-emitting diode displays, etc., are examples of photo-emitting displays and liquid-crystal displays, electrochromic displays, electrophoresis

displays, electro-optical crystal displays, etc., are examples of photo-receiving displays. Although these thin display elements each have advantages and disadvantages, by means of photo-emitting display elements, a bright display is obtained, but there is a disadvantage in that the driving voltage is high and the power consumption is high, while by means of photo-receiving elements, the power consumption is generally low, but there is a disadvantage in that it is difficult to see the display in dark places because the display is a photo-receiving type that does not emit light. Therefore, efforts have been made to enclose the surrounding light using a reflecting structure with photo-receiving display elements. However, it is almost impossible to see the display when the surrounding light is weak. Consequently, in many cases, a light source for providing lighting to the back is often used in photo-receiving light elements. Nevertheless, when a light source for lighting is used, energy consumption increases and the advantage of low energy consumption of photo-receiving display elements is therefore lost. Consequently, in order to obtain a bright display that is not inferior to that of photo-emitting display elements and to reduce as much as possible the energy consumption, it is necessary to use as efficiently as possible the irradiated light from the light source for lighting in display with transmission-type display elements. In the past this has been accomplished with, for instance, a structure where the irradiated light from a fluorescent lamp is repeatedly reflected by being placed behind the transparent substrate of a liquid-crystal display element inside the transparent substrate as it is efficiently irradiated over the entire display surface (Proceedings of the Third Liquid Crystal Symposium, page 24, 1977). Nevertheless, as yet it has been impossible to obtain a sufficiently bright display with low energy consumption using photo-receiving display elements with this type of structure. For instance, a luminance of only 20 nit is obtained at the display image plane, even when a

light source for lighting with a luminance of 400 nit at 4W is used in liquid crystal display elements that house active matrix-type color filters, which have recently received attention as thin display elements with which color display is possible with a large display volume that can rival that of CRT. Moreover, even when compared to 1.5-inch color CRT with which a luminance of 40 nit is obtained at an energy consumption of 4W, the brightness of the image plane is inferior. Therefore, the authors devised a photo-receiving display element of a new structure with which the irradiated light from a light source for lighting or ambient light can be efficiently used in display and as a result, they completed this invention.

[Objective of Invention]

The objective of this invention is to present a photo-receiving display element with which display of a bright image plane is possible.

[Structure of invention]

The transmission-type display element of this invention is characterized by the fact that it is a transmission-type display element with which at least one piece of a transparent substance is used as the substrate of the display substance and display is performed as the irradiated light from the back of said substrate is controlled by the aforementioned display substance, and by the fact that a microlens array is formed by working the back surface of the aforementioned substrate.

(Example 1)

This invention will now be explained in detail while referring to the figures.

Figure 1 is a diagram showing the structure of one piece of the substrate used in an example of the transmission-type display element of this invention. In

Figure 1, 1 is a glass substrate with a thickness of 1.3 mm, 2 is the TFT (thin film transistor) made from amorphous silicon, 3 is the Mo drain electrode, 4 is the Mo gate electrode, and 5 is the indium oxide picture element electrode (transparent electrode). Although not shown in the figure, drain electrode 3 and gate electrode 4 are separated at their point of intersection by a silicon nitride insulating film. Figure 2 is the structure of one example of the transmission-type display element of this invention that was made using the substrate in Figure 1. It is the AA' cross section of the substrate in Figure 1. In Figure 2, 1 is the glass substrate that is shown in Figure 1 and 2, 3, and 5 are the TFT, the drain electrode and the picture element electrode, respectively, formed on glass substrate 1. Microlens array 11 is formed on the back of substrate 1. This microlens array was formed by mechanically polishing the glass substrate surface. 6 is a glass substrate with a thickness of 1.1 mm. Dot-like color filter 8, was placed on top of this so that it corresponds to indium oxide common electrode 7 and picture element 5, which cover the entire surface. Furthermore, three types, red, blue and green, of color filter 8 are used. The edges of 2 pieces of glass substrate 1 and 6 are bonded and fixed with epoxy adhesive 9 and liquid crystal substance 10 containing black dichroic pigment is filled into this space to obtain a so-called guest-host liquid crystal display element housing an active-matrix color filter. The liquid crystal substance in this example is the display substance, and the transparent substance is two pieces of glass substrate used as the substrate of this display substance. The liquid crystal substance shows well-known guest-host electro-optical effects in accordance with the voltage waveform selectively applied to gate electrode 4, drain electrode 3 and common electrode 7. That is, almost all irradiated light from the back of glass substrate 1 is transmitted with "picture element on ", while almost all irradiated light from the back of glass substrate 1 is absorbed and not

transmitted with "picture element off". The transmitted light is colored by the color filter formed in accordance with each picture element electrode and can therefore be seen. As a result, color display or red, blue, green and their mixed colors on a black background is eventually realized.

[Effects and results of invention]

The results obtained with microlens array 11 are explained using Figure 3. Figure 3 is a diagram of part of glass substrate 1 in Figure 2 drawn approximately at a reduced scale. 12 is the state where the irradiated light is transmitted by the liquid crystal substance with "picture element on", or the so-called region of the aperture. That is, irradiated light is controlled by the electro-optical effects of the guest-host liquid crystal substance, as shown in Figure 1. The so-called picture element region is the region of picture element electrode 5 in Figure 1 only and the area outside this region is normally blocked to irradiated light. In this example, the surface area occupied by the picture element electrode in Figure 1 is approximately 60% of the total. The length of aperture 12 in Figure 3 is 180 μm and the distance between apertures is 70 μm. In Figure 3, of the light irradiated from the back of glass substrate 1, the light that takes on light path 20 directly proceeds through aperture 12 to participate efficiently in display. Moreover, the irradiated light that passes through light path 21 or 22 is refracted by microlens array 11 formed on the back of substrate 11 and eventually passes through aperture 12 to participate efficiently in display. That is, all of the irradiated light passes through aperture 12 to participate efficiently in display on the inside of the transmission-type display element of the aforementioned example in Figure 3. Nevertheless, as shown by the broken line in Figure 3, in conventional structures where there is no microlens array 11, the irradiated light proceeds directly as 31 and 32 and reaches regions without an

aperture. As a result, this light is not efficiently used in display. In this example, when a light source for lighting with a luminance of 400 nit is placed behind glass substrate 12, display luminance of 28 nit is obtained and there is marked improvement when compared to the display luminance of 20 nit when a microlens array is not used. As a result, a bright image plane is displayed. Of course, even when there was no separate light source for lighting, the transmission-type display element of this example provided a bright image plane when compared to the conventional structure. Furthermore, although converging effects were not obtained with respect to an aperture in the direction parallel to a semicircular columnar lens (perpendicular to AA' into the plane of the paper in Figure 1) because a semicircular columnar microlens array was made in this example, the effects were improved further by using a microlens array of semispherical microlenses in an array. In this example, display luminance was improved from 28 nit to 33 nit.

[Examples 2 and 3]

Figures 4 and 5 are cross sections showing the shape of the glass substrate that was used in the microlens arrays of other examples of this invention. Figure 4 shows the cross section of a "V-groove" microlens array and Figure 5 shows the cross section of a "trapezoid" microlens array. In these examples, the effects were exactly the same as in the case of the "semicircular columnar" microlens array in Figure 2 and a bright image plane was displayed when compared to the transmission display elements of a conventional structure. Moreover, although the aforementioned examples have described liquid crystal display elements that house active-matrix color filters, the results of this invention are not limited to systems that house color filters or to active-matrix systems, and the operating mode of the liquid crystal display substance is not

limited to the guest-host type. However, in active-matrix systems whereby the display substance, such as a liquid crystal substance is operated by connecting switching elements to each picture element, there is a marked reduction in the aperture of the display image plane when these switching elements are used and therefore, the effects of this invention are further enhanced. Moreover, the amount of light transmitted, that is, luminance, is markedly reduced when the wavelength of the incident light is selected by the color filter, even in liquid crystal display elements where the color filter array is set up in a position corresponding to each picture element and therefore, the effects of this invention are clearly realized.

[Example 4]

Figure 6 shows the fourth example of this invention and is the case where an electrochromic material was used as the display substance. Only one piece of substrate can be used when an electrochromic substance is used as the display substance. 41 is the glass substrate and 42 is the TFT molded from polysilicon. 43 is the Mo drain electrode, 45 is the tin oxide picture element electrode, 50 is the tungsten oxide layer of the display substance, 52 is the magnesium fluoride layer that serves as the ion conducting layer, 47 is the tin oxide common electrode, and 51 is the irregular part of the "semicylindrical" microlens array formed on the back of glass substrate 41. In this case the effects and results were the same as in the aforementioned examples.

Furthermore, the display substance is not limited to the substances discussed in the aforementioned examples. It goes without saying that this invention is effective even when other substances, for instance, electro-optical crystals, such as conventional electrochromic materials and materials known by the name of PLZT, or magneto-optical crystals, such as carbonates, etc.; are

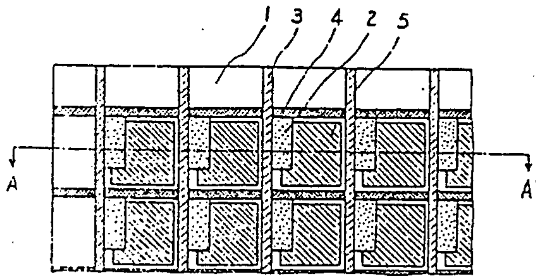
used.

As previously explained, by means of this invention, a photo-receiving display element with which display of a bright image plane is possible is obtained.

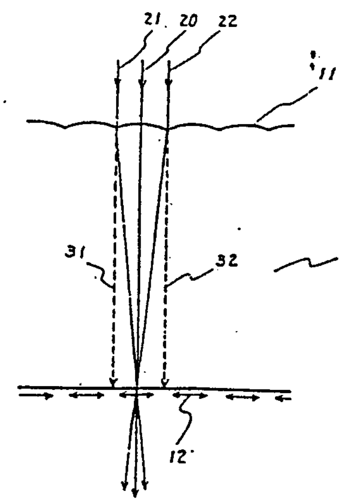
Brief Explanation of Figures

Figure 1 is a diagram showing 1 piece of substrate in one example of this invention. 1 is the glass substrate, 2 is the thin film transistor, 3 is the drain electrode, 4 is the gate electrode, and 5 is the picture element electrode. Figure 2 is a cross section of the structure of one example of this invention. 1, 2, 3 and 5 are the same as in Figure 1, 11 is the irregular microlens array, 6 is the glass substrate, 7 is the counter electrode, 8 is the color filter, 9 is the adhesive, and 10 is the display substance. Figure 3 is a diagram that explains the results of the example in Figure 2. 1 and 11 are the same as in Figure 2 and 12 is the display aperture, 20, 21 and 22 are the light paths of irradiated light, and 31 and 32 are, by way of comparison, the light path of irradiated light in a conventional structure where microlens array 11 was not used. Figures 4, 5 and 6 show the cross section of substrates used to form the microlens array of other examples of this invention.

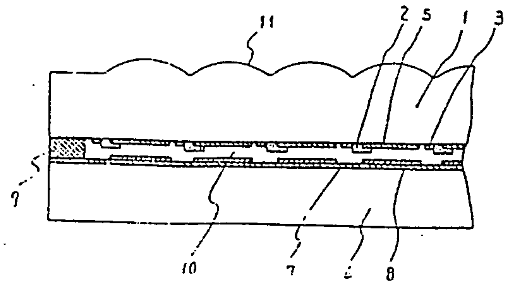
第 1 図



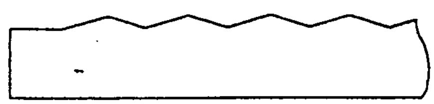
第 3 図



第 2 図



第 4 図



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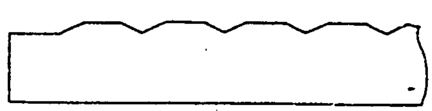

第 6 図